

CLAIMS

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1. A method of generating plasma in a toroidal plasma generator, said toroidal plasma generator comprising a gas passage having a gas entrance and a gas outlet, said gas passage forming a 10 circuitous path, and a coil wound around a part of the gas passage,

characterized in that said method comprises the steps of supplying a mixed gas of an Ar gas and an NF₃ gas containing at least 5% of said NF₃ gas, and 15 igniting plasma by driving said coil with a high-frequency power,

said step of igniting plasma being conducted under a total pressure of 6.65-66.5Pa.

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2. The method of generating plasma as claimed in claim 1, characterized in that said mixed 25 gas contains NF₃ by a concentration of 5% or more but not exceeding 45% in said plasma ignition step.

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3. The method of generating plasma as claimed in claim 1, characterized in that said mixed gas in said plasma ignition step contains NF₃ with a

concentration of 10% or more but not exceeding 45% in said plasma ignition step.

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4. The method of generating plasma as
claimed in claim 1, characterized in that said mixed
gas contains NF₃ with a concentration of 20% or more
10 but not exceeding 45% in said plasma ignition step.

15 5. The method of generating plasma as
claimed in claim 1, characterized in that said method
further comprises, after said step of igniting plasma,
a step of increasing a total pressure of said mixed
gas.

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25 6. The method of generating plasma as
claimed in claim 5, characterized in that said step of
increasing said total pressure of said mixed gas is
conducted while maintaining said concentration of NF₃
in said mixed gas at constant.

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7. The method of generating plasma as

claimed in claim 5, characterized in that said step of increasing the total pressure of said mixed gas is conducted while changing said concentration of NF_3 in said mixed gas.

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8. The method of generating plasma as
10 claimed in claim 5, characterized in that said mixed gas contains NF_3 , after said step of increasing said total pressure of said mixed gas, with a concentration of 5 - 40%.

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9. The method of generating plasma as
claimed in claim 1, characterized in that said mixed
20 gas is supplied with a flow rate of 100SCCM or less in said plasma ignition step.

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10. The method of generating plasma as
claimed in claim 1, characterized in that said mixed gas is supplied with a flow rate of 3SCCM or more but not exceeding 80SCCM.

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11. A method of generating plasma in a toroidal plasma generator, said toroidal plasma generator comprising a gas passage having a gas entrance and a gas outlet, said gas passage forming a 5 circuitous path, and a coil wound around a part of said gas passage,

characterized in that said method comprises the steps of supplying a mixed gas of an Ar gas and a F₂ gas containing at least 5% of said F₂ gas, and 10 igniting plasma by driving said coil with a high-frequency power,

said step of igniting plasma being conducted under a total pressure of 6.65-66.5Pa.

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12. The method of generating plasma as claimed in claim 11, characterized in that said mixed 20 gas contains F₂ with a concentration of 5% or more but not exceeding 45%.

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13. The method of generating plasma as claimed in claim 11, characterized in that said method further comprises, after said ignition step, a step of increasing a total pressure of said mixed gas.

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14. The method of generating plasma as
claimed in claim 13, characterized in that said step
of increasing said total pressure of said mixed gas is
conducted while maintaining said concentration of F₂
5 in said mixed gas at constant.

10 15. The method of generating plasma as
claimed in claim 13, characterized in that said step
of increasing said total pressure of said mixed gas is
conducted while changing said concentration of F₂ in
said mixed gas.

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20 16. The method of generating plasma as
claimed in claim 11, characterized in that said mixed
gas is supplied with a flow rate of 100SCCM or less in
said plasma ignition step.

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17. A cleaning method for cleaning a
processing vessel evacuated by an evacuating system
and coupled with a remote plasma source,
30 said remote plasma source comprising a
toroidal plasma generator, said toroidal plasma
generator comprising a gas passage having a gas
entrance and a gas outlet, said gas passage forming a

circuitous path, and a coil would around a part of said gas passage,

characterized in that said cleaning method comprises the steps of:

5 forming radicals containing F in said remote plasma source; and

supplying said radicals to an interior of said processing vessel and cleaning said interior of said processing vessel by said radicals,

10 said step of forming said radicals comprising the steps of:

supplying a mixed gas containing at least 5% of NF_3 or F_2 in an Ar gas to said gas passage as a cleaning gas with a first pressure in which plasma can 15 ignite and igniting plasma by driving said coil by a high-frequency power; and

increasing a total pressure of said mixed gas in said gas passage to a second pressure while maintaining said plasma,

20 said cleaning step cleaning said interior of said processing vessel at said second pressure.

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18. The cleaning method as claimed in claim 17, characterized in that said step of increasing said total pressure of said mixed gas comprises a step of changing a conductance of said evacuation system and a 30 step of changing a flow rate of said mixed gas.

19. The cleaning method as claimed in claim
17, characterized in that said step of changing said
total pressure of said mixed gas is conducted by
changing a conductance of said evacuation system and a
5 flow rate of said mixed gas simultaneously.

10 20. The cleaning method as claimed in claim
17, characterized in that said step of changing said
total pressure of said mixed gas comprises a step of
decreasing a conductance of said evacuation system
while maintaining a flow rate of said mixed gas
15 constant, and a step of increasing said flow rate of
said mixed gas while maintaining said total pressure
constant.

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21. The cleaning method as claimed in claim
20, characterized in that said method further
comprises a step of increasing said flow rate of said
25 mixed gas while holding said conductance of said
evacuation system maximum.

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22. The cleaning method as claimed in claim
17, characterized in that said step of changing said
total pressure of said mixed gas comprises a step of

switching plural mass flow controllers.

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23. The cleaning method as claimed in claim
17, characterized in that said step of increasing said
total pressure of said mixed gas is conducted while
maintaining said concentration of said cleaning gas in
10 said mixed gas constant.

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24. The cleaning method as claimed in claim
17, characterized in that said step of increasing said
total pressure of said mixed gas is conducted while
changing said concentration of said cleaning gas in
said mixed gas.

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26. The cleaning method as claimed in claim
17, characterized in that said cleaning step is
conducted by setting said concentration of NF_3 in said
mixed gas to 50-40%.

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26. The cleaning method as claimed in claim
17, characterized in that said mixed gas is supplied

with a flow rate of 100SCCM or less in said plasma ignition step.

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27. The cleaning method as claimed in claims 17 - 26, characterized in that said mixed gas contains NF₃ as said cleaning gas and wherein said 10 first pressure is set to 6.65-66.5Pa.

15 28. The cleaning method as claimed in claim 27, characterized in that said mixed gas contains NF₃, in said plasma ignition step, as said cleaning gas with a concentration of 5% or more but not exceeding 45%.

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25 29. The cleaning method as claimed in claim 27, characterized in that said mixed gas contains NF₃, in said plasma ignition step, as said cleaning gas with a concentration of 10% or more but not exceeding 45%.

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30. The cleaning method as claimed in claim

m 27, characterized in that said mixed gas contains NF₃, in said plasma ignition step, with a concentration of 20% or more but not exceeding 45%.

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31. The cleaning method as claimed in claim 17, characterized in that said mixed gas contains F₂ 10 as said cleaning gas, and wherein said first pressure is set to 6.65 - 66.5Pa.

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32. The cleaning method as claimed in claim 31, wherein said mixed gas contains F₂, in said plasma ignition step, as said cleaning gas with a concentration of 5% or more but not exceeding 45%.

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33. A substrate processing method in a 25 processing vessel evacuated by an evacuation system and coupled with a remote plasma source,

characterized in that said remote plasma source comprises a toroidal plasma generator comprising a gas passage having a gas entrance and a 30 gas outlet and forming a circuitous path, and a coil would around a part of said gas passage,

said substrate processing method comprising the steps of:

forming radicals containing F in said remote plasma source; and

etching a surface of a substrate to be processed in said processing vessel by said radicals

5 by supplying said radicals to an interior of said processing vessel,

said step of forming said radicals comprising the steps of:

supplying a mixed gas containing NF₃ or F₂

10 in an Ar gas with a concentration of at least 5% to said gas passage under a first pressure in which ignition of plasma is possible and igniting plasma by driving said coil with a high-frequency power; and

increasing a total pressure of said mixed

15 gas in said passage to a second pressure while maintaining said plasma,

said step of etching being conducted under said second pressure.

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34. The substrate processing method as claimed in claim 33, characterized in that said step

25 of increasing said total pressure of said mixed gas comprises a step of changing a conductance of said evacuation system and a step of changing a flow rate of said mixed gas.

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35. The substrate processing method as

claimed in claim 33, wherein said step of changing said total pressure of said mixed gas is conducted by changing a conductance of said evacuating system and a flow rate of said mixed gas simultaneously.

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36. The substrate processing method as
10 claimed in claim 33, characterized in that said step
of changing said total pressure of said mixed gas
comprises a step of decreasing a conductance of said
evacuation system while maintaining a flow rate of
said mixed gas constant, and a step of increasing said
15 flow rate of said mixed gas while maintaining said
total pressure constant.

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37. The substrate processing method as
claimed in claim 36, characterized in that said method
further comprises a step of increasing said flow rate
of said mixed gas while holding said conductance of
25 said evacuation system maximum.

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38. The substrate processing method as
claimed in claim 33, characterized in that said step
of changing said total pressure of said mixed gas
comprises the step of switching plural mass flow

controllers.

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39. The substrate processing method as
claimed in claim 33, characterized in that said step
of increasing said total pressure of said mixed gas is
conducted while maintaining said concentration of said
10 etching gas in said mixed gas constant.

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The substrate processing method as claimed
in claim 33, characterized in that said step of
increasing said total pressure of said mixed gas is
conducted while changing said concentration of said
etching gas in said mixed gas.

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41. The substrate processing method as
25 claimed in claim 33, characterized in that said
etching step is conducted by setting said
concentration of NF_3 in said mixed gas to 50-40%.

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42. The substrate processing method as
claimed in claim 33, characterized in that said mixed

gas is supplied in said plasma ignition step with a flow rate of 100SCCM or less.

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43. The substrate processing method as claimed in claim 33, characterized in that said mixed gas contains NF₃ as said etching gas, and wherein said 10 first pressure is set to 6.65 - 66.5Pa.

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44. The substrate processing method as claimed in claim 43, characterized in that said mixed gas contains NF₃ in said plasma ignition step as said etching gas with a concentration of 5% or more but not exceeding 45%.

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45. The substrate processing method as claimed in claim 43, characterized in that said mixed gas contains NF₃ as said etching gas in said plasma ignition step with a concentration of 10% or more but not exceeding 45%.

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46. The substrate processing method as

claimed in claim 43, characterized in that said mixed gas contains NF_3 as said etching gas in said plasma ignition step with a concentration of 20% or more but not exceeding 45%.

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47. The substrate processing method as
10 claimed in claim 33, characterized in that said mixed gas contains F_2 as said etching gas and wherein said first pressure is set to 6.65 - 66.5Pa.

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48. The substrate processing method as
claimed in claim 47, characterized in that said mixed
gas contains F_2 as said etching gas in said plasma
20 ignition step with a concentration of 5% or more but
not exceeding 45%.

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49. A cleaning method for cleaning an
interior of a processing vessel by plasma-excited
radicals of a cleaning gas under a first pressure
zone, characterized in that said method comprises the
30 steps of:

introducing a mixed gas of a diluting gas
and a cleaning gas to a plasma generator under a
second pressure lower than said first pressure and

igniting plasma; and

increasing a pressure inside said processing vessel to said first pressure zone from said second pressure zone.

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10 50. The cleaning method as claimed in claim 49, characterized in that said cleaning gas contains a halogen compound.

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51. The cleaning method as claimed in claim 49, characterized in that said cleaning gas contains NF_3 .

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52. The cleaning method as claimed in claim 49, characterized in that said cleaning gas contains 25 F_2 .

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53. The cleaning method as claimed in claim 49, characterized in that said diluting gas is selected from any of Ar, Kr and Xe.

54. The cleaning method as claimed in claim 49, characterized in that said plasma generator is a toroidal plasma generator.

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55. The cleaning method as claimed in claim 49, characterized in that said plasma generator is any 10 one of a capacitive-coupled plasma generator, an induction-coupled plasma generator, an ECR plasma generator, a helicon wave plasma generator, and a microwave cavity plasma generator.

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56. A substrate processing method for etching a surface of a substrate to be processed by 20 plasma-excited radicals under a first pressure zone, comprising the steps of:

introducing a mixed gas of a diluting gas and an etching gas into a plasma generator under a second pressure lower than said first pressure and 25 igniting plasma; and

increasing a pressure inside said processing vessel to said first pressure zone from said second pressure zone.

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57. The substrate processing method as

claimed in claim 56, characterized in that said etching gas contains a halogen compound.

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58. The substrate processing method as claimed in claim 56, characterized in that said etching gas contains NF_3 .

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59. The substrate processing method as
15 claimed in claim 56, characterized in that said etching gas contains F_2 .

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60. The substrate processing method as claimed in claim 56, characterized in that said diluting gas is selected from any of Ar, Kr and Xe.

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61. The substrate processing method as claimed in claim 56, characterized in that said plasma
30 generator is a toroidal type plasma generator.

62. The substrate processing method as claimed in claim 56, characterized in that said plasma generator is any one of a capacitive-coupled plasma generator, an induction-coupled plasma generator, an 5 ECR plasma generator, a helicon wave plasma generator, and a microwave cavity plasma generator.

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63. A cleaning method for cleaning an interior of a processing vessel by plasma-excited radicals of a cleaning gas under a first pressure zone, comprising the steps of:

15 introducing a mixed gas of a diluting gas and a cleaning gas into a plasma generator under a second flow rate zone smaller than said first flow rate zone and igniting plasma; and

increasing a flow rate of said mixed gas 20 from said first flow rate zone to said second flow rate zone.

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64. The cleaning method as claimed in claim 63, characterized in that said cleaning gas contains a halogen compound.

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65. The cleaning method as claimed in claim

63, characterized in that said cleaning gas contains NF₃.

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66. The cleaning method as claimed in claim 63, characterized in that said cleaning gas contains F₂.

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67. The cleaning method as claimed in claim 15 63, characterized in that said diluting gas is selected from any of Ar, Kr and Xe.

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68. The cleaning method as claimed in claim 63, characterized in that said plasma generator is a toroidal plasma generator.

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69. The cleaning method as claimed in claim 30 63, characterized in that said plasma generator is any one of a capacitive-coupled plasma generator, an induction-coupled plasma generator, an ECR plasma generator, a helicon wave plasma generator, and a microwave cavity plasma generator.

70. A substrate processing method for
etching a surface of a substrate to be processed in a
processing vessel by plasma-excited radicals of
etching under a first flow rate zone, comprising the
5 steps of:

introducing a mixed gas of a diluting gas
and an etching gas into a plasma generator under a
second flow rate zone smaller than said first flow
rate zone and igniting plasma; and
10 increasing a flow rate of said mixed gas
from said second flow rate zone to said first flow
rate zone.

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71. The substrate processing method as
claimed in claim 70, characterized in that said
cleaning gas contains a halogen compound.

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72. The substrate processing method as
25 claimed in claim 70, characterized in that said
cleaning gas contains NF₃.

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73. The substrate processing method as
claimed in claim 70, characterized in that said
cleaning gas contains F₂.

74. The substrate processing method as claimed in claim 70, characterized in that said diluting gas is selected from any of Ar, Kr and Xe.

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75. The substrate processing method as claimed in claim 70, characterized in that said plasma 10 generator is a toroidal plasma generator.

15 76. The substrate processing method as claimed in claim 70, characterized in that said plasma generator is any one of a capacitive-coupled plasma generator, an induction-coupled plasma generator, an ECR plasma generator, a helicon wave plasma generator, 20 and a microwave cavity plasma generator.